Report: October 1980 to September 1981 and continuation to February 1982. NPS contract number CX70290029. TAMU-RF Project No. 4366.

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National Park Service
U.S. Department of the Interior
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## Abstract/Conclusions

The ultimate objective of this research is to determine the maximum amount of groundwater available for National Park use near Panther Junction, Big Bend Park, Texas. The project is partially complete. Due to a large mountainous catchment, we expect Green Gulch to be an important source of recharge. Bedrock aquifers will be evaluated on the basis of surface outcrops, logs, seismic and gravity data. Alluvial aquifers and recharge conditions can be evaluated with surface exposures, logs, seismic and electrical resistivity. Past drilling, recent surface sampling, and a rain gauge network provide hydrologic data.

All of the alluvial fans are thought to be relatively old and to contain many impermeable calcareous horizons. Map patterns of rock types are complicated. Folded and faulted sedimentary and volcanic rocks are disrupted by plutonic igneous rocks. The sandy layers of the Aguja Formation are the probable bedrock aquifers; they may be locally water-enriched or impoverished where cut by intrusive (plutonic) rocks (probably the situation at K-bar). Bedrock topography dips in the same direction as fan surfaces but has NE-SW trending undulations (old stream courses). Gravel is twenty to one-hundred feet thick. Recharge through the bulk of the fans is probably inhibited by the presence of calcareous horizons.

It will be useful to drill several test wells during phase III in order to further check geophysical interpretations, collect samples, and determine hydrologic properties.

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## PROJECT OVERVIEW

The ultimate objective of this research is to determine the maximum amount of groundwater available for National Park use near Panther Junction (Fig. 1). Since the primary source of water is from groundwater it is important that the groundwater system be defined and a water management program be established for the Park. Increased visitor pressure and use of the Big Bend National Park has resulted in increased demands of water resources. Proposed development of facilities for Park staff and visitors at Panther Junction (Fig. 2) will result in water need (Anonymous, 1979, 1980). Development of facilities will be partly in response to ecologic sensitivity of The Basin (Whitson, 1974) and resulting need to redirect some types of development to Panther Junction.

The scope of the entire (multi-year) investigation is as follows:

1. Quantify the annual recharge to the principal aquifer presently supplying water to production wells and to other main rock units within the study area.

2. Determine if the well sources of water are hydraulically connected to the springs.

3. Quantify the maximum amount of ground water available for withdrawal from producing wells without affecting the flow of any spring.

The method of investigation is broken into five phases. The first three phases deal with hydrologic, geologic and chemical evaluation. Data will be gathered and analyzed. The last two phases will deal primarily, but not exclusively, with data synthesis, especially water budget and management. Some tasks of the early phases are to be continued throughout the study, such as hydrologic measurements. The first two phases of the study are outlined below:

Phase I (First year continuing into second year)

A. General investigation

1. General features:

a) Aerial photography interpretation

b) Aerial observation and photography using rented aircraft (except the basin).

c) Stratigraphy - Structure: study of present interpretations.

2. Equipment:

a) Ordering rain gauges, portable weather station.

b) Establishment of preliminary water level and rain gauge recording networks.

3. Evaluation of existing weather and ground-water data.

4. Inventory of wells and springs:

a) Amount of production from wells.

b) Amount of spring flow.

c) Chemical quality of water.

5. Stratigraphy and structure of the rocks:

a) Initiate study to improve details and interpretations.

6. Aquifer geometry:

a) Preliminary definition.

Phase II (Second year)

A. Phase I Continuation.

B. Stratigraphy and structure of the rocks:

1. Comprehensive study to improve details and interpretations.

2. Evaluate need for additional test wells.

C. Aquifers:

1. Geometry:

a) Seismic refraction study on shallow aquifer (In alluvium and terrace gravels).

b) Evaluate need for additional test wells.

2. Hydrologic Properties:

a) Porosity estimates or measurements.

b) Permeability measurements.

c) Transmissivity.

1. Pumping tests.
2. Site selection.
3. Evaluate need of new observation wells.

We are currently in the second year and first two phases of the study.

Excellent progress has been made. In January 1981, two sets of air photos were qualitatively evaluated. They added little to our knowledge except that we decided after reviewing them that the cost of flying over the site for aerial observation was not justified. Studies by Maxwell and others (1967, 1968), Henry (1965), and Walton and Henry (1979) gave us a regional geologic picture. Details of rock structure are reviewed by Maxwell and others (1967, 1968); stratigraphy is discussed in Maxwell and others (1967, 1968), Hopkins (1968), Korshak (1973), and Miller (1978). Both computer bibliographic searches and hand searches turned up little else in terms of regional geology or hydrology that is applicable to our study. We established a precipitation recording network in Spring 1981 (installed by the Weather Bureau with supervision by Mr. Garland Moore of the National Park Service). Under the direction of Mr. Garland Moore a regional temperature-precipitation study was made (Christensen, 1981). We have visited and sampled

wells and springs. Geologic logs, geophysical logs and chemical data are available for several wells and chemical analyses are at hand for some springs. We are correlating all these data. We have conducted surface geophysical studies, the results of which are partially evaluated. Porosity and permeability measurements are currently being made on rock samples collected from sections of rock strata that have been described in published literature or theses, and which occur within or adjacent to the study locus. Because of all that we have accomplished and because of our need to use pump tests to evaluate transmissivity and other hydrologic parameters, test wells will be needed during Phase III, and by Fall 1982 we will be ready to site them.

## PROJECT RESULTS

Discussion of results is loosely sequenced as follows: hydrology, topography, geology, geophysics. Figures 3 through 17 present results or information concerning project status.

A simple map outlining drainage basins (Fig. 3) reveals that some basins (such as I or III) have an average elevation controlled by roughly equal areas of steep fans and mountains versus alluvial plains. However, Basin IV has little high land. But Basin II covers an extensive mountainous area that drains mostly into Green Gulch. A regional report for the Big Bend area by Christensen (1981) tends to confirm the notion that precipitation increases with elevation. He found a 0.218 mm increase in annual precipitation with each meter of elevation change (or 2.7 inches per 1000 feet) (ten stations, as on Fig. 1, with correlation coefficient equals 0.82). Consequently, we expect groundwater movement through the bed of Green Gulch to be a major source of recharge.

Rain gauges are distributed over the study area (Fig. 4) in order to determine the area and temporal variability of precipitation on a monthly and yearly basis. Stations at Panther Junction and The Basin will have about thirty years of record at the end of this study. The other stations will have about four years for comparison.

Wells in Figure 5 include production wells at Panther Junction and K-Bar, in addition to various test wells and observation wells. Most of the wells were drilled in the mid-1960's. Lithologic and/or geophysical logs are available for these sites. Correlations of logs are incomplete.

During pumping tests of the K-Bar wells in January 1982, we found considerable encrustation and deterioration of casings. It was also difficult to conduct pump tests because of low pump rates due to small pumps and a probable period of general groundwater rise (due to high rainfalls of the past few seasons). We are attempting to locate and copy data from tests conducted in the 1960's by the U.S. Geological Survey on the Lone Mountain and other wells.

Water chemical information is available for twenty-five wells and springs (Fig. 6). We resampled eight of these in January 1982, to confirm original measurements and detect changes during the past fifteen years since the first sampling. Results of analyses are not yet available for the recently collected samples. The older results have been partly evaluated and show some grouping of wells on the basis of carbonate content and other parameters. Multivariate statistical analysis may prove fruitful for the study of chemical constituents. Chemical composition of waters is controlled by exposed and underground rock types.

Topography (Fig. 7) can be divided into alluvial fan and mountain components. Mountain topography consists of talus slopes (porous, permeable, coarse-grained) and exposed rock (variable hydrologic properties). Alluvial fan topography consists of arroyos cut into the gravel surfaces, this is significant in that these fan surfaces seem to be dominated by erosion of previously deposited gravel. Apparently the more dissected fans in Figure 7 are the older ones. The fans as a group are being eroded by streams in the Croton Spring region. Thus all the fans are thought to be relatively old, perhaps they are all Tertiary age (pre-glacial). Consequently, it is not surprising that we

find many impermeable calcareous horizons within the upper fan sediments as exposed by arroyos or in the landfill.

Figure 8 graphically portrays alluvial gravel vs. exposed rock (including talus). This "simple" map is enough for the reader to realize the complexity of bedrock patterns to be expected at depth and under the gravels. The plutonic rocks are irregular in size and shape. The folded and faulted sedimentary and volcanic (layered) rocks are further disrupted by the plutonic (intruded) rocks. The plutonic rocks near K-Bar, Panther Junction and Lone Mountain may serve as barriers to groundwater flow in the sedimentary rocks, thus creating water-rich zones and accounting for the production from wells in those areas. The most likely sedimentary rock aquifers are the sandy layers of the Aguja Formation.

To get a better knowledge of porosity and permeability, as well as first hand observation of rock texture, etc., samples were collected. Collection sites, Figure 9, were located along measured stratigraphic sections as reported in the literature. About thirty specimens are being measured in the lab.

Geophysical data is partly evaluated (Figs. 10-17). Seismic surveys (Fig. 10) have been interpreted in the Green Gulch - Lone Mountain area but await further evaluation near Panther Junction and K-Bar. Additional work may be done near springs this summer. Cross-sections A, B and C in Figure 11 display depths and soil/rock types based on seismic interfaces and velocities. The seismic interfaces give depths to strata of different rigidities while the velocities of p-waves (sound waves) indicate material types. Wells are used to check the interpretations. These sections clearly show the gravel thickness,

bedrock interface, and near-surface rock type. The 1200 ft/sec velocity zone indicates weathered debris near the surface. Ambiguity of interpretations are shown. Our final interpretation for D will include additional information from electrical resistivity and surface exposures of rock. However, sections A, B and C are close to their final form.

From the seismic sections in Figure 11 we can generate a map of bedrock topography (Fig. 12). Because section D is not fully interpreted, the far west portion of the map is tentative. As additional data is interpreted we will expand the map to incorporate the Panther Junction and K-Bar areas. In Figure 13 we show one possible drainage pattern for the bedrock surface, under the gravels. Although specific, ancient stream courses might be drawn a little differently, any drawing will be dominated by NE-SW trends. Also, the topography clearly indicates that the rock surface slopes in the same direction as the modern gravel surface. We can carry this discussion a step further; Figure 14 shows the thickness of gravel between the land surface and the bedrock surface. The elongate, thick zones are due mainly to bedrock topographic undulations.

Electrical resistivity surveys (Fig. 15) will provide data regarding surficial aquifers and upper rock. We have not produced any interpretative maps at this time. The electrical resistivity technique measures changes in electrical conductivity; clays or water-bearing materials are usually the most conductive, dry limestone is one of the least. Gravity surveys (Fig. 16) require data corrections and interpretation that will not be completed until summer. Gravity measurements will help us to understand the bedrock geometry such as a horizontal change from sedimentary rocks to plutonic igneous rocks. In gravity studies

we are actually detecting changes in earth density. Preliminary interpretation of the magnetic survey, Figure 17, simply indicates that near-surface variations in iron content of the rocks and sediments is insufficient to cause anamolies in the magnetic field.

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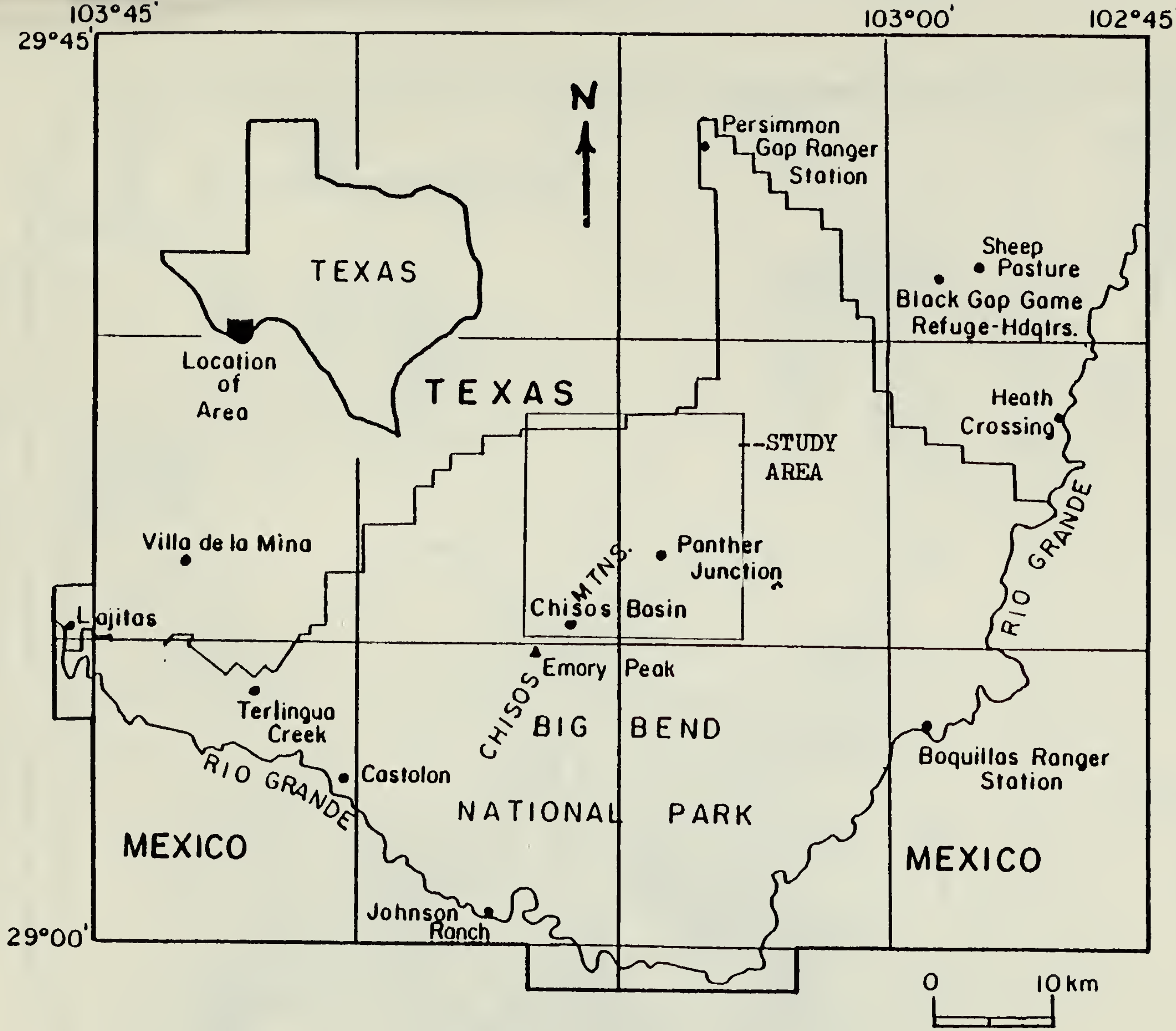


**Figure 1. Location Map**
(from Christensen, 1981)

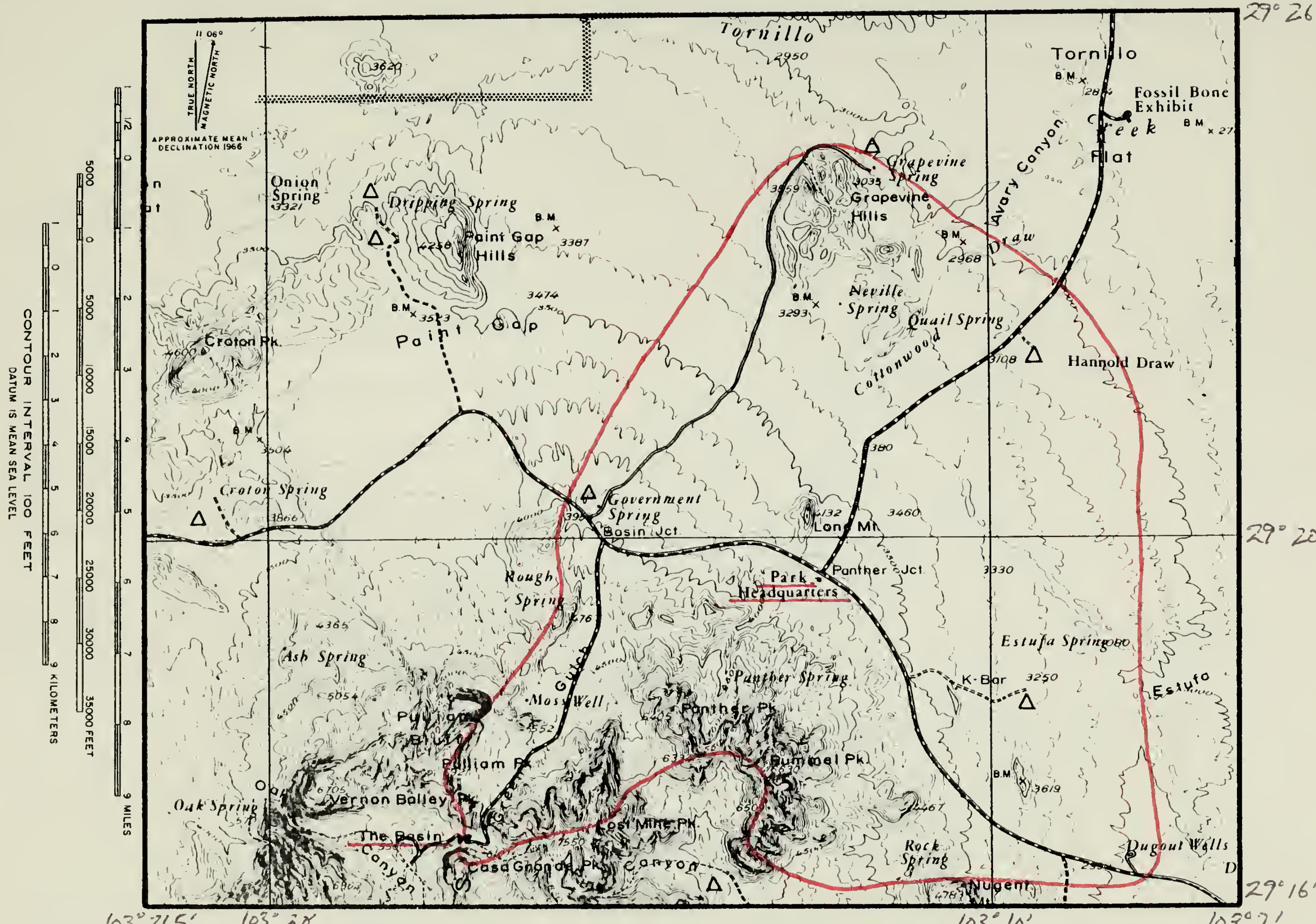


Figure 2. PRIMARY STUDY LOCUS

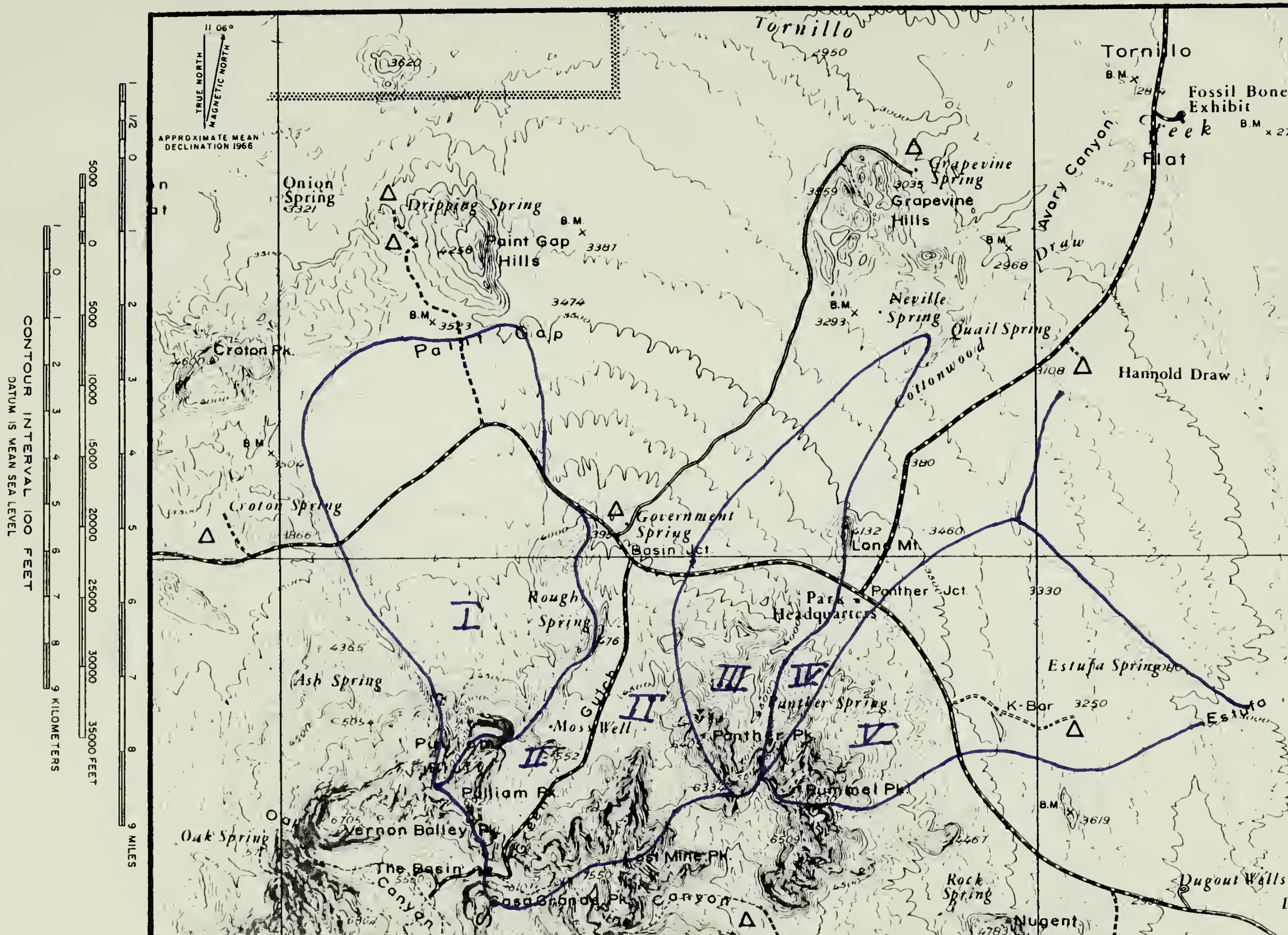


FIGURE 3. Drainage Basins

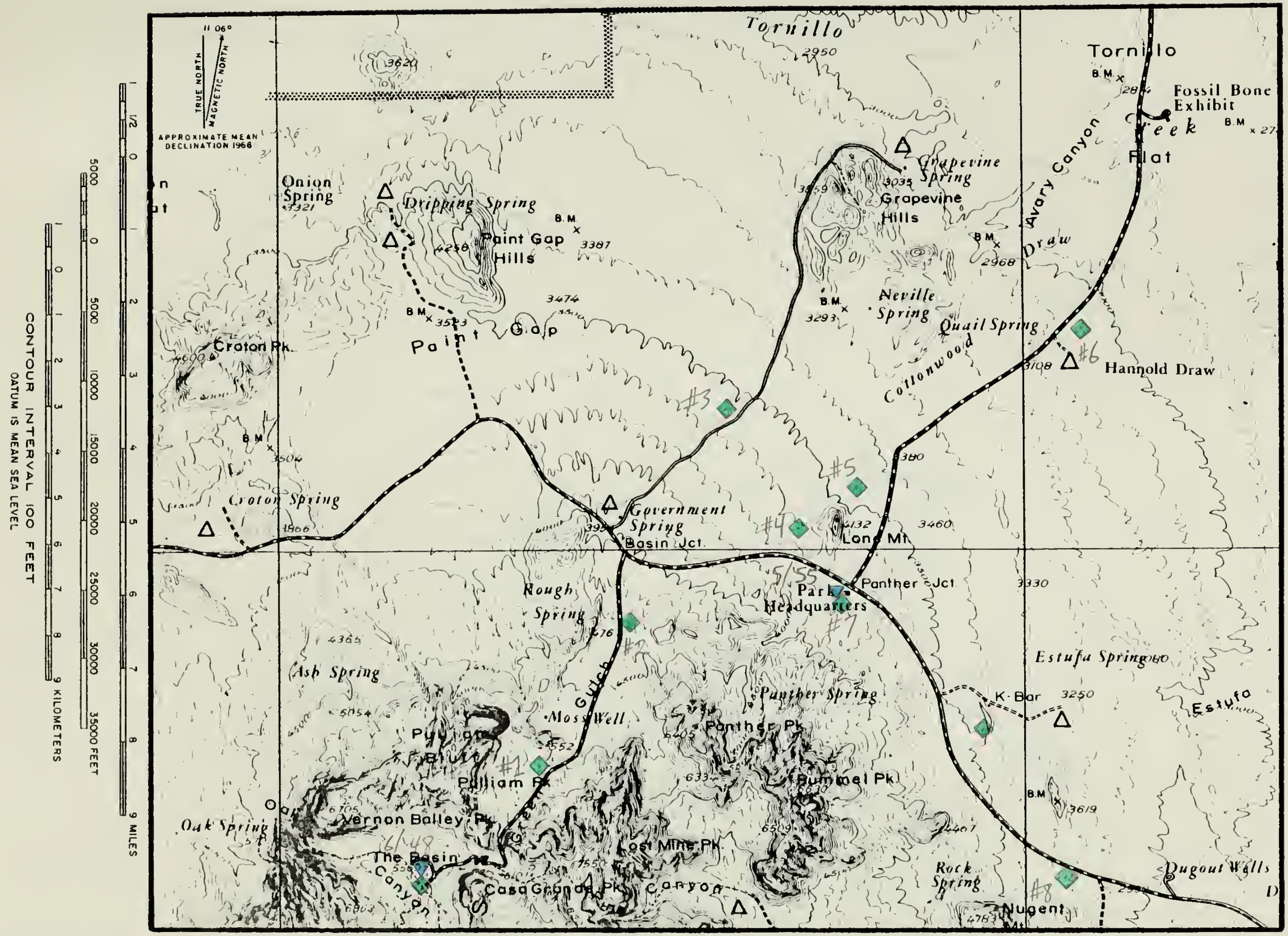


FIG. 4. Rain gauges

Permanent rain station (with date of first record)

Temporary rain gauge (with gauge number)

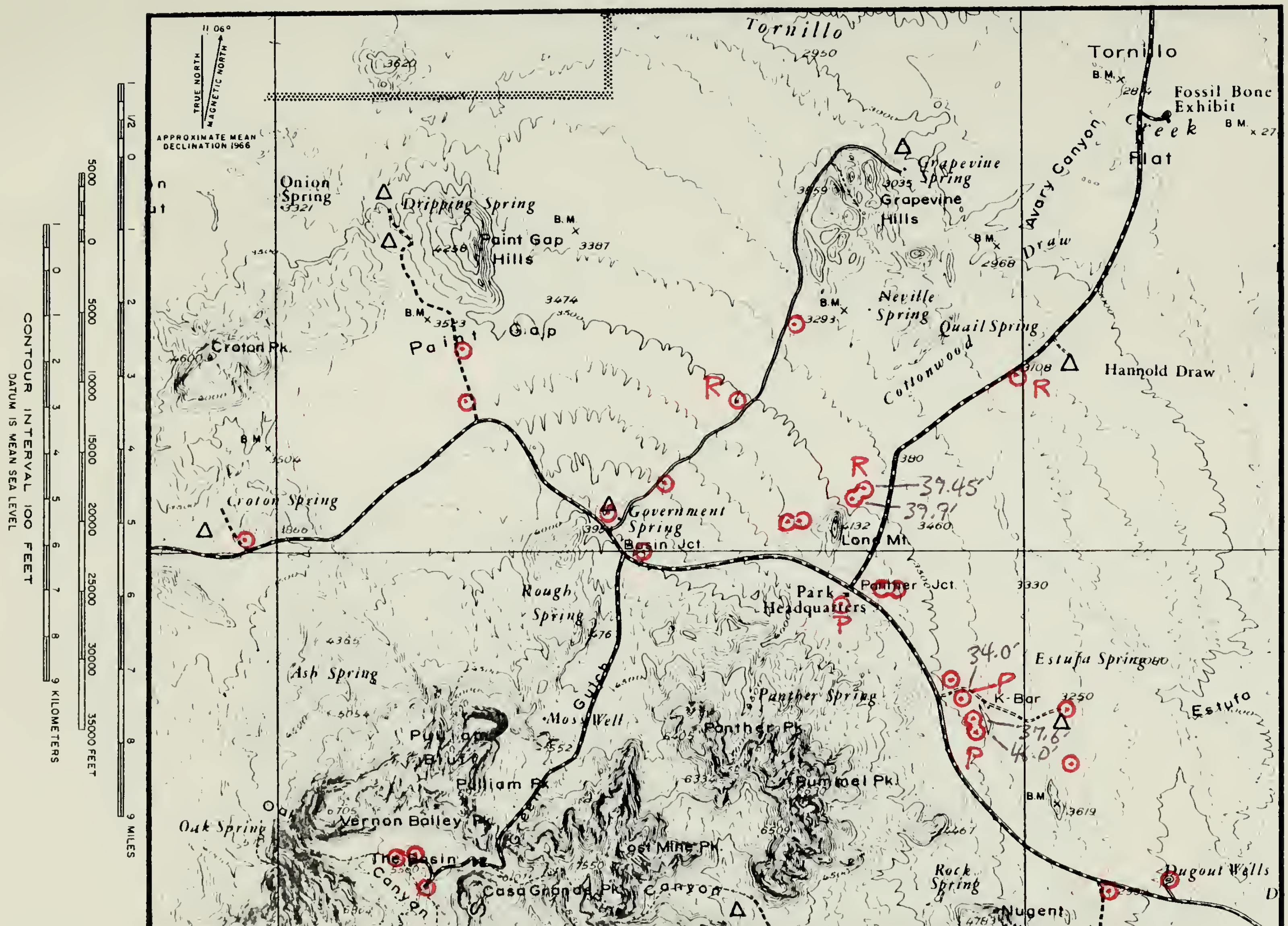


FIG. 5. Wells

well
R well with recorder
P Production well

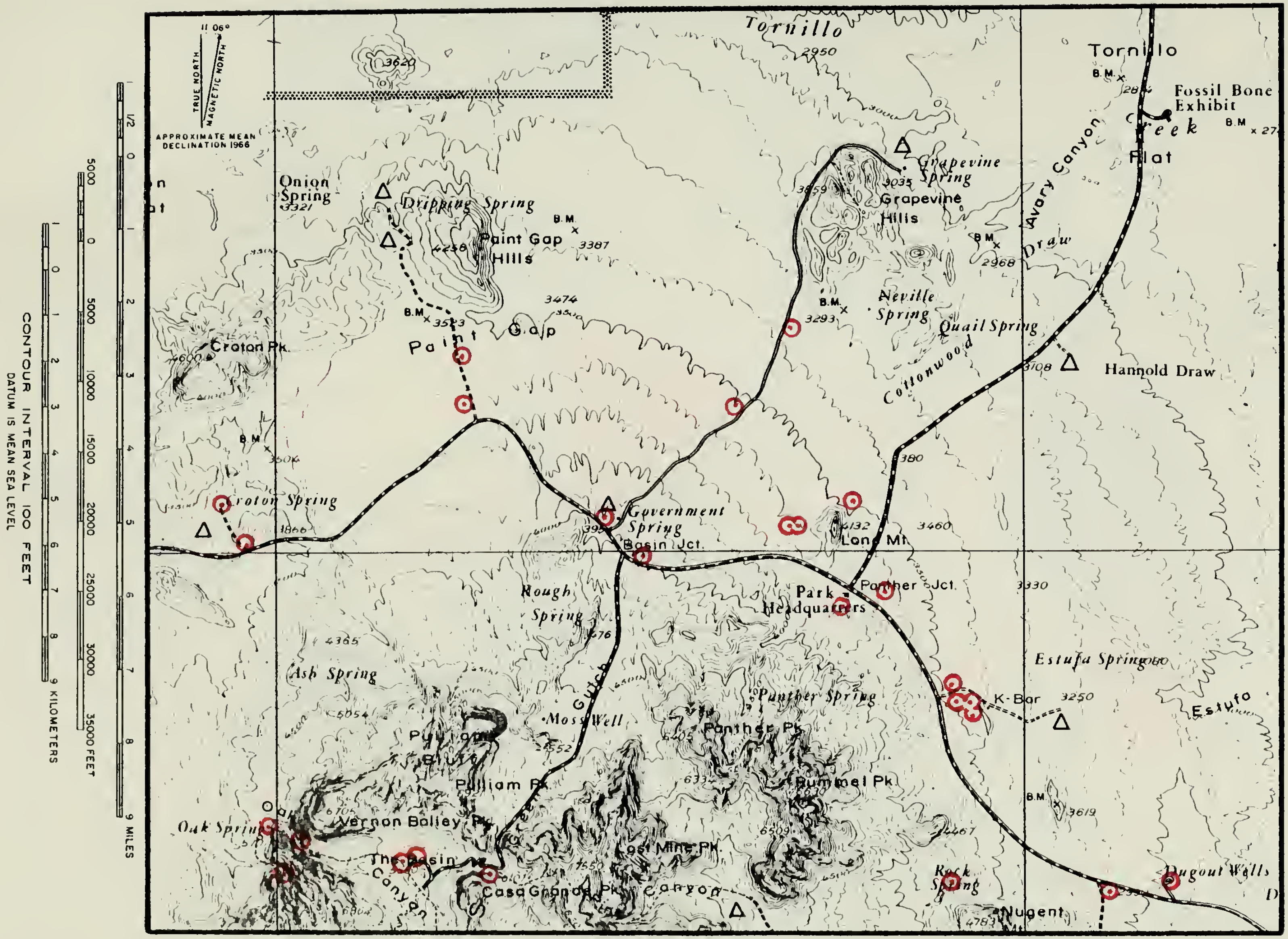


FIG. 6. Hydrogeochemistry

⊙ wells + springs

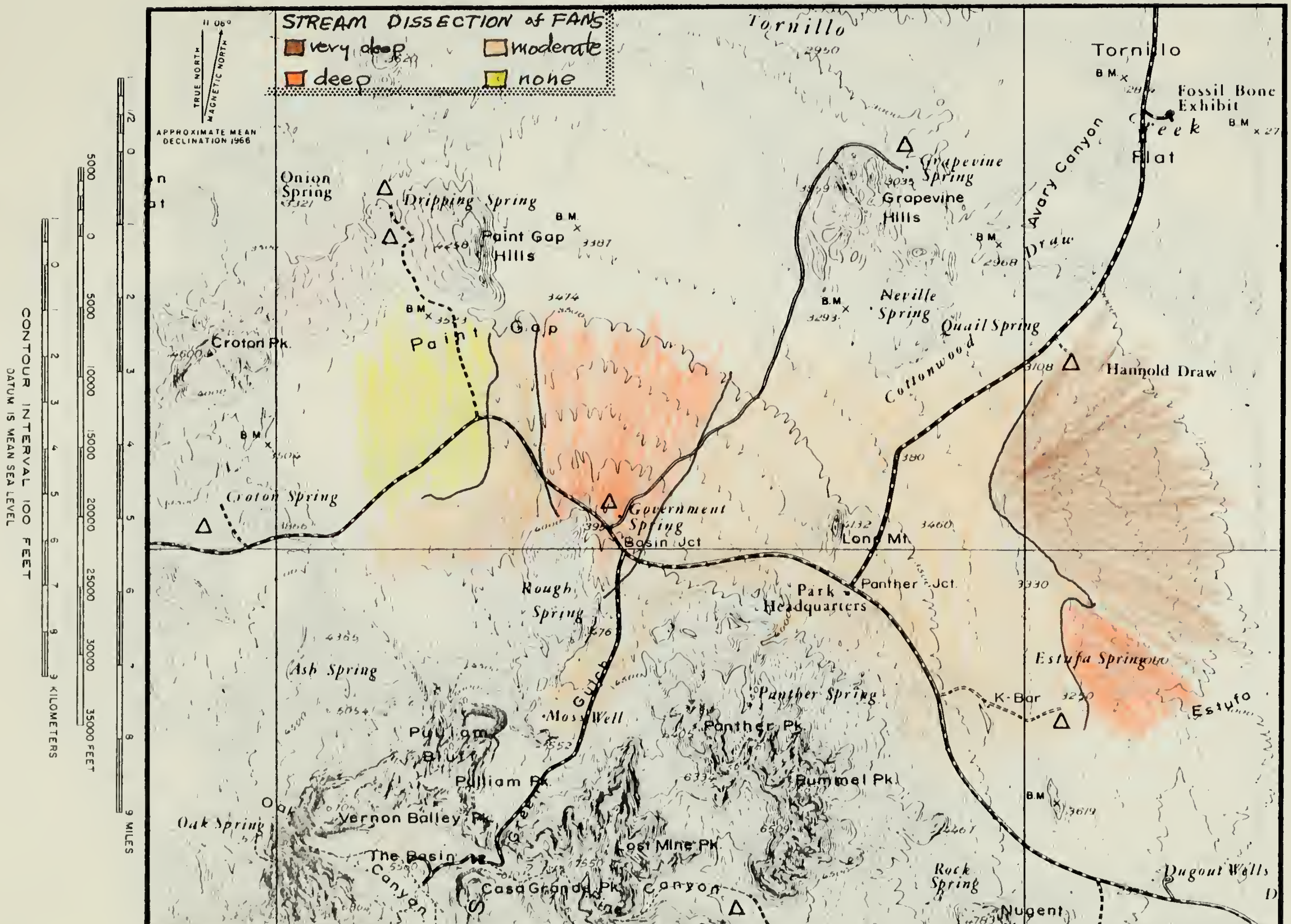


FIG. 7. Topography

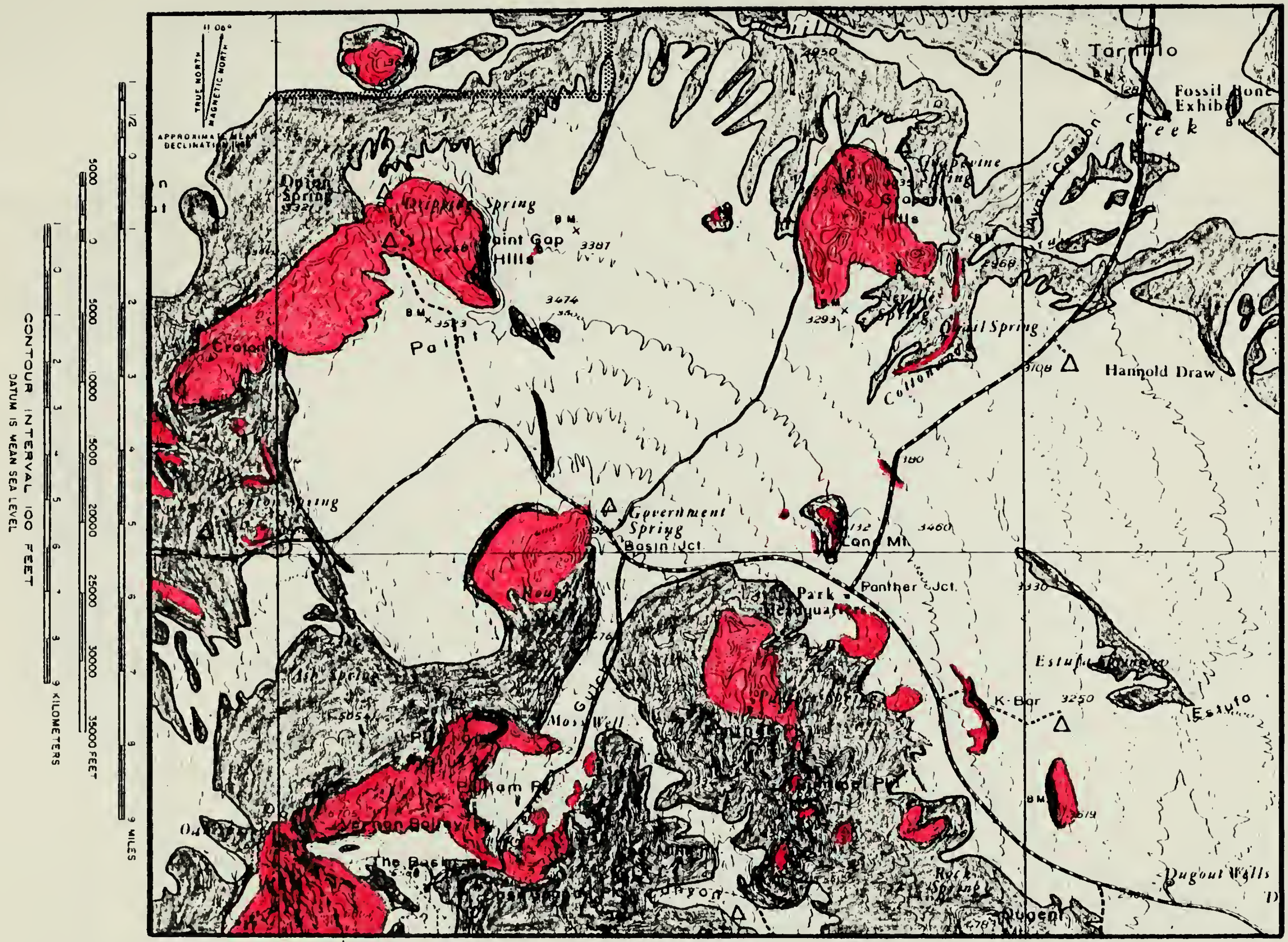


FIGURE 8. EXPOSED ROCK

Sedimentary & Volcanic

Plutonic Igneous

(modified from Maxwell and others, 1966)

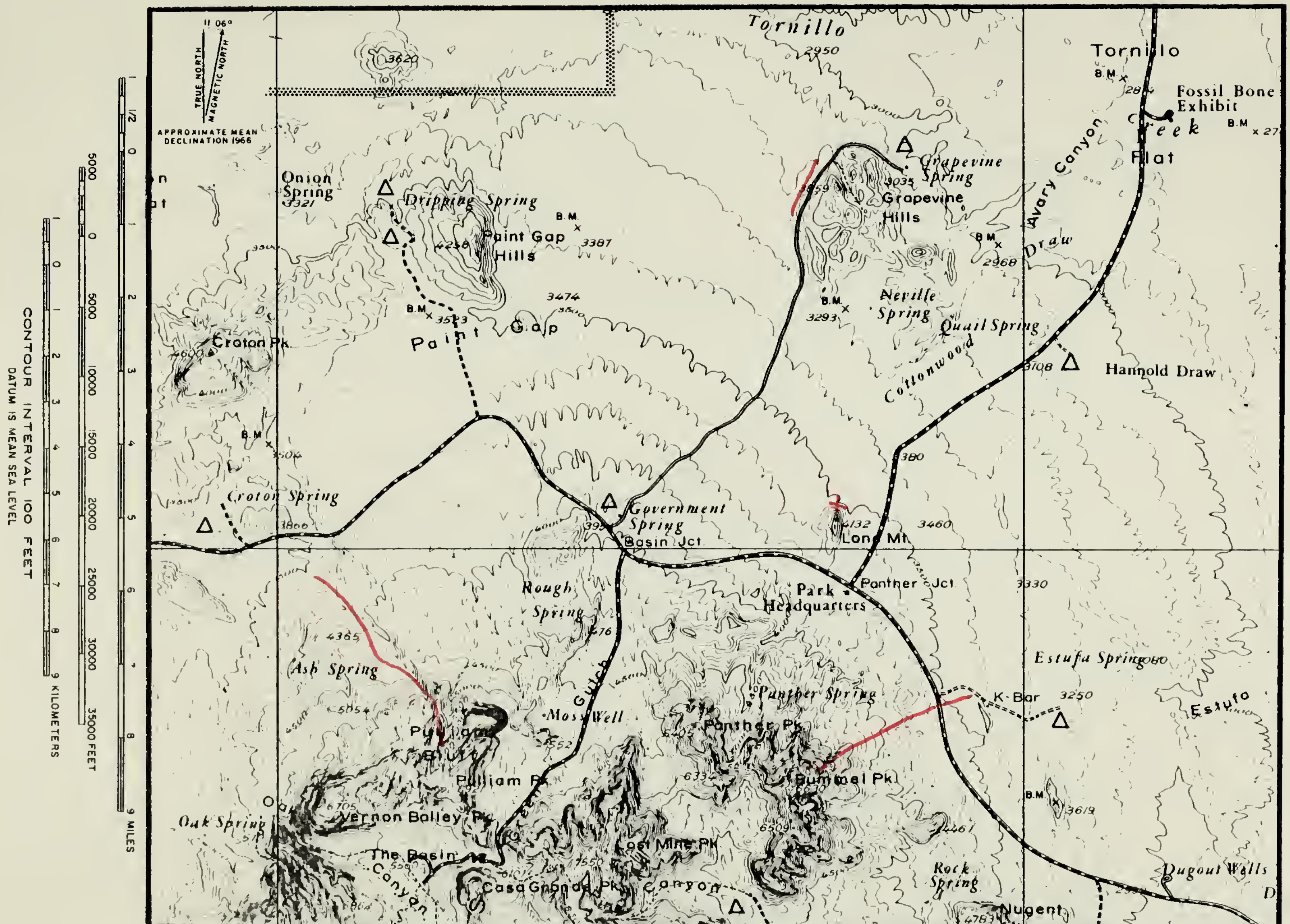


FIG. 9. Sources of Rock Samples

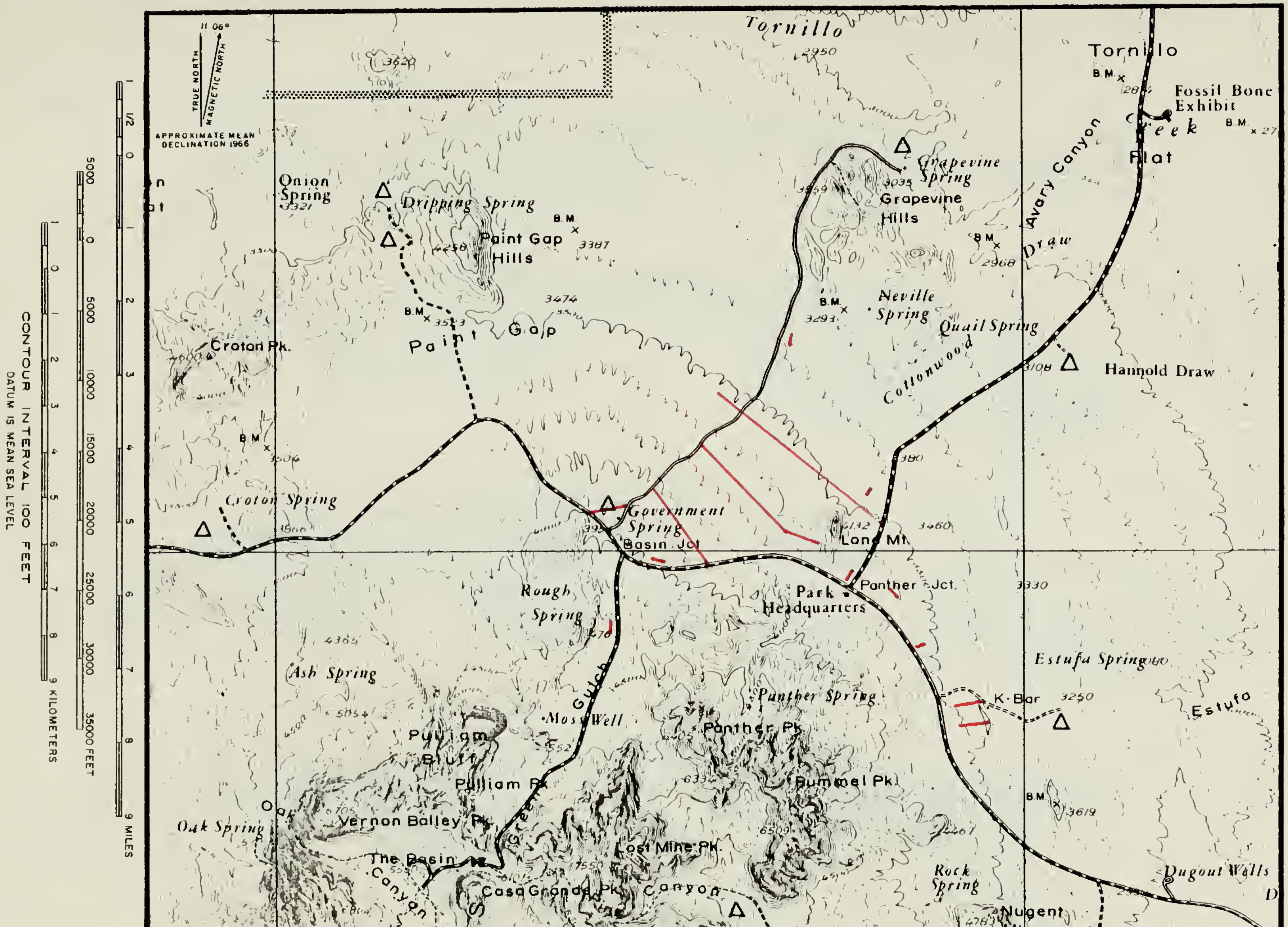


FIG. 10. Seismic Survey

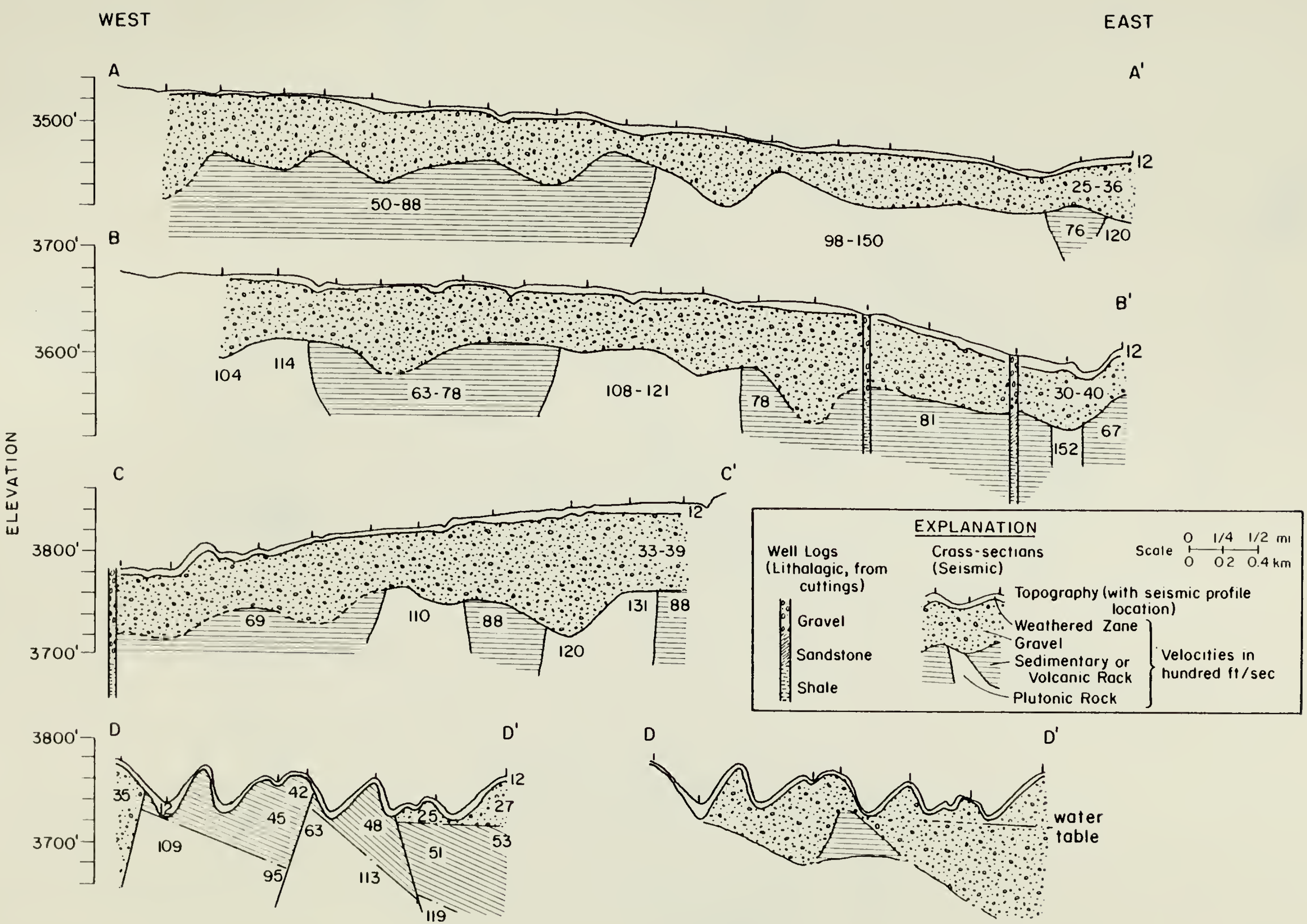


FIGURE 11. SEISMIC SECTIONS


N
HIGHWAY 118 TO ALPINE
HIGHWAY 385 TO MARATHON
BASIN JUNCTION
TO BASIN
PANTHER JUNCTION
LONE MTN
(intrusive outcrop)
3500
3600
3700
3800
MAP OF BEDROCK TOPOGRAPHY
CONTOUR INTERVAL 100 ft.
0 1000' 2000'
HIGHWAY
Contour on top of rock in subsurface
Contour IMPLIED FROM GEOLOGIC MAP (surface or near surface) by MAXWELL, etal (1967)

FIGURE 12.


MAP OF BEDROCK TOPOGRAPHY

CONTOUR INTERVAL 100 ft.

0 1000' 2000'

FIGURE 13.

| | |
|---|---|
| ——— | HIGHWAY |
| Contour ~~~ | on top of rock in subsurface |
| Contour - - - | IMPLIED FROM GEOLOGIC MAP (surface or near surface) by MAXWELL, et al. (1967) |

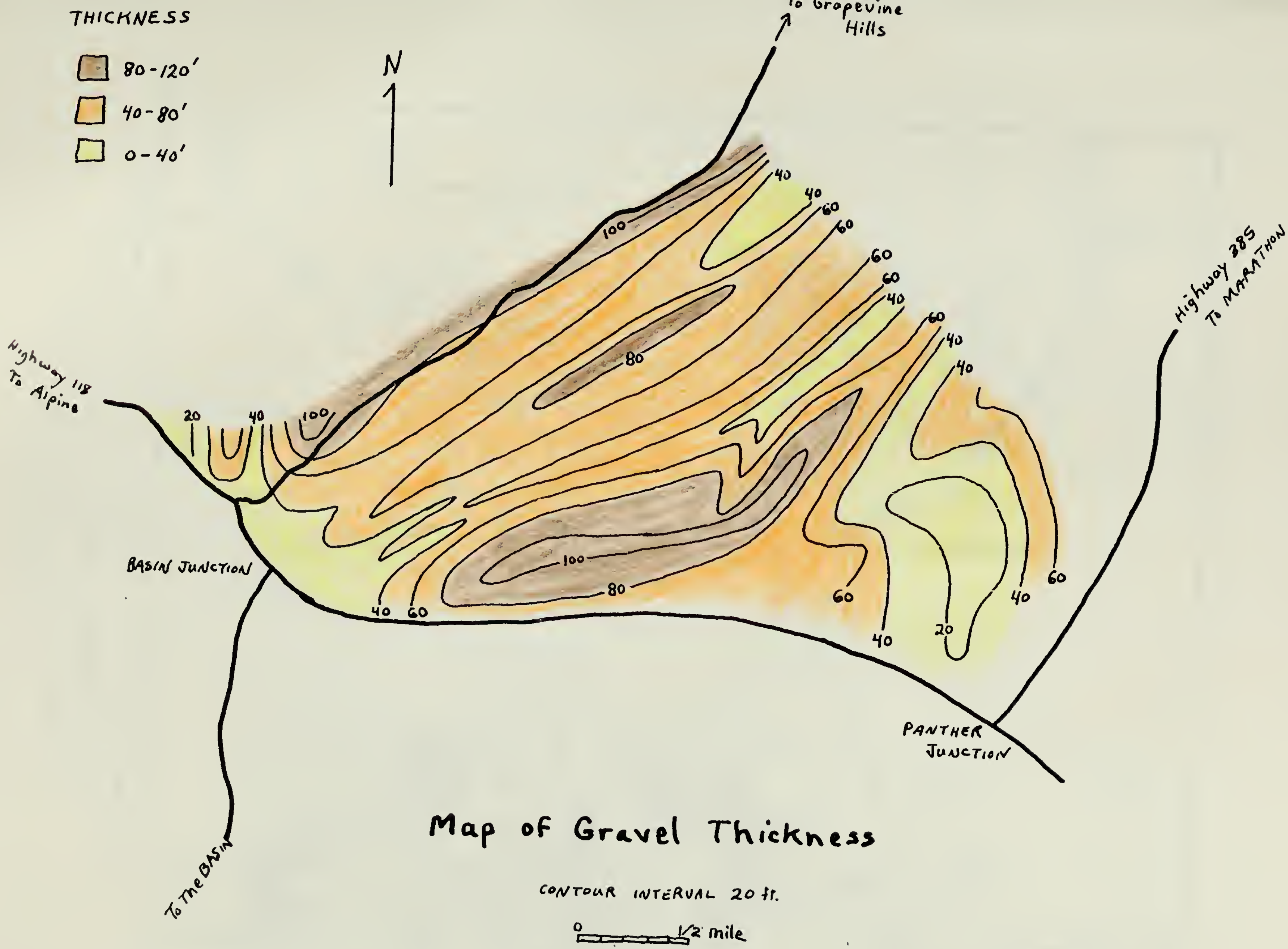
THICKNESS
80-120'
40-80'
0-40'
N
To Grapevine Hills
Highway 385 To MARATHON
Highway 118 To Alpine
BASIN JUNCTION
PANTHER JUNCTION
To The BASIN
Map of Gravel Thickness
CONTOUR INTERVAL 20 ft.
0
1/2 mile

Figure 14.

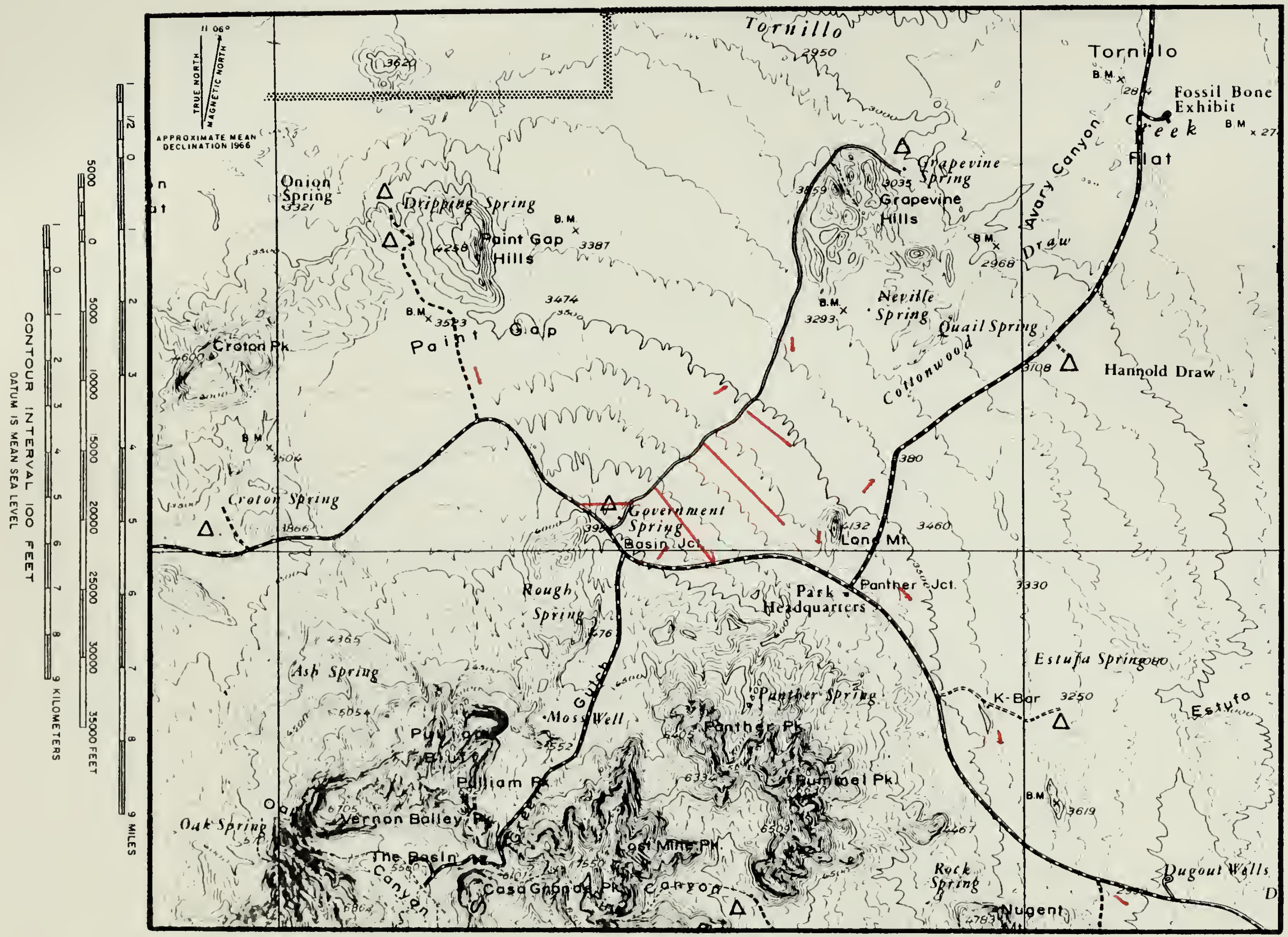


Fig. 15. Electrical Resistivity Survey

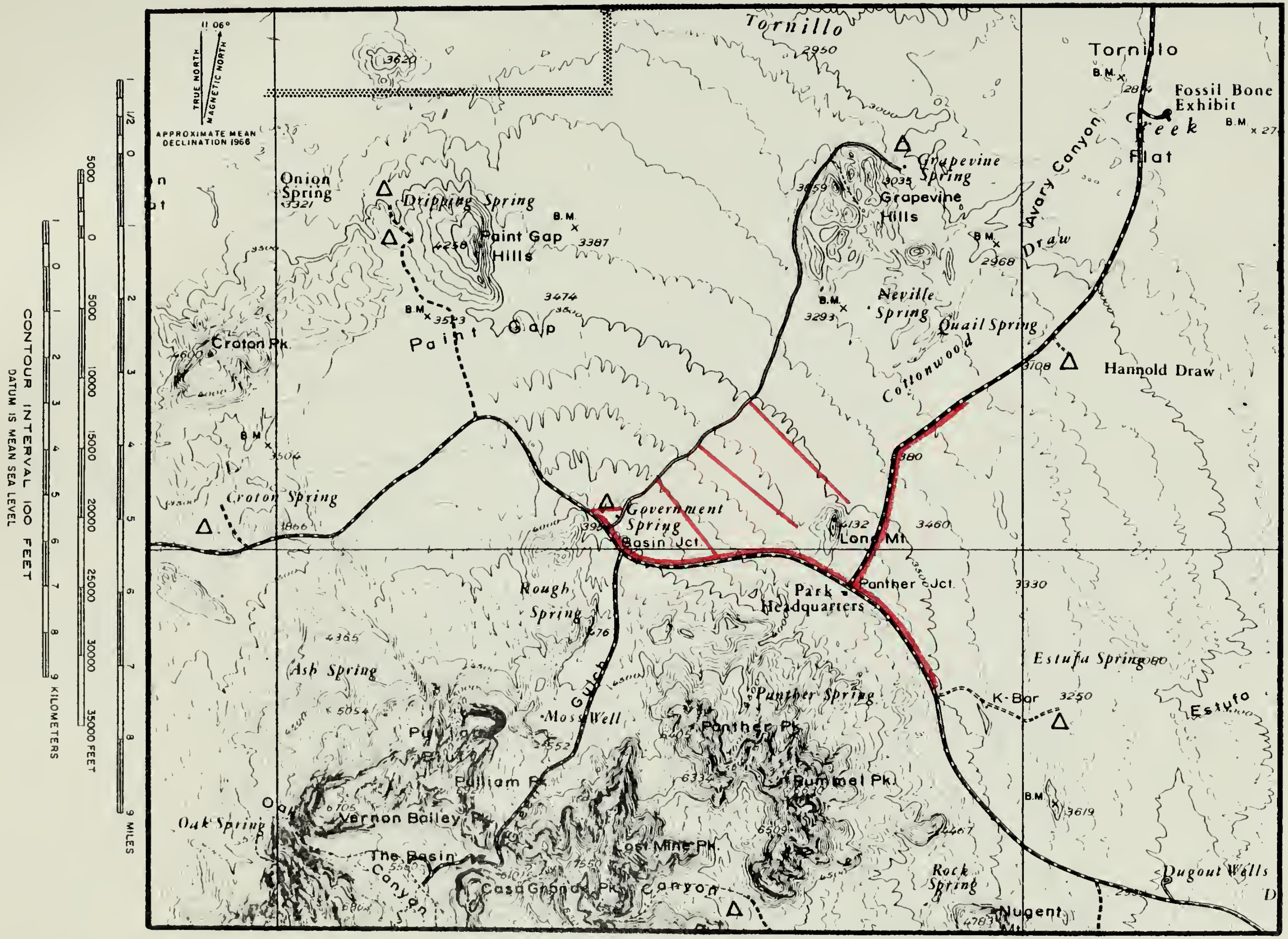


Fig. 16. Gravity Survey

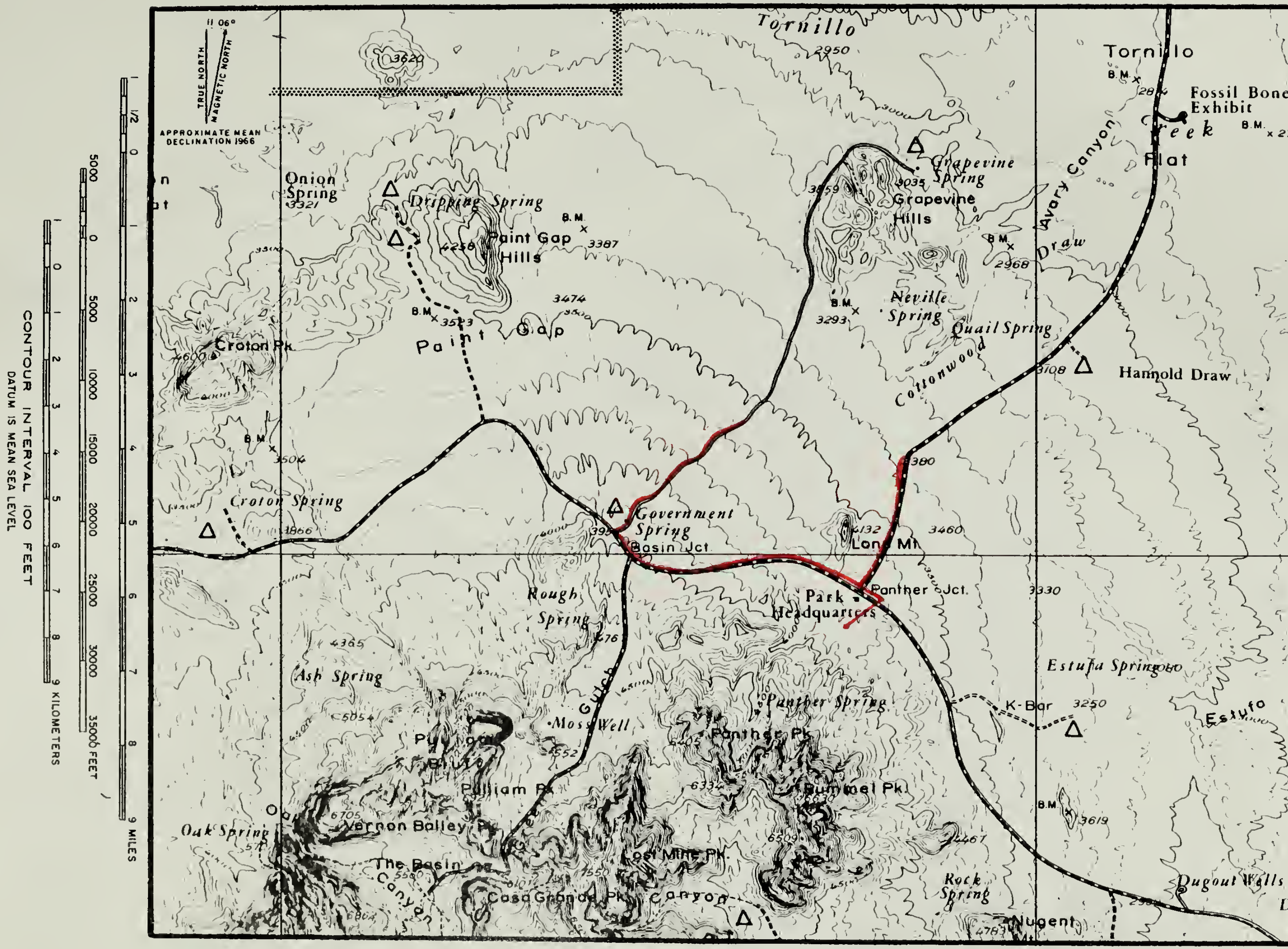


Fig. 17. Magnetic Survey